

USE OF SPRAY COATINGS TO ACHIEVE NON-UNIFORM SEAL CLEARANCES IN TURBOMACHINERY

BACKGROUND OF THE INVENTION

[0001] The invention relates to seal clearances in rotary machines. More particularly, the invention relates to a method to modify the stationary casing in a manner to compensate for circumferentially non-uniform rotor movements.

[0002] Rotary machines include, but are not limited to, gas turbines and steam turbines. The moving part of the turbine is called a rotor and the fixed, non-moving part i. e. housings, casings etc. a stator. Usually, the rotor rotates within a stator assembly at very high speeds, powering a generator which in turn produces electricity or power. A steam turbine has a steam path that typically includes, in serial-flow relationship, a steam inlet, a turbine, and a steam outlet. A gas turbine has a gas path, which typically includes, in serial-flow relationship, an air intake (or inlet), a compressor, a combustor, a turbine, and a gas outlet (or exhaust nozzle). Gas or steam leakage, either out of the gas or steam path or into the gas or steam path, from an area of higher pressure to an area of lower pressure, is generally undesirable. For example, gas path leakage in the turbine or compressor area of a gas turbine, between the rotor of the turbine or compressor and the circumferentially surrounding turbine or compressor casing, will lower the efficiency of the gas turbine leading to increased fuel costs.

[0003] In practice, clearances between the rotating and stationary parts are often designed to be sufficiently large so that minimal contact occurs during the operation of the engine. However, overly generous clearances tend to promote undesirable leakages and decreased performance. In some machine designs, where reduced clearances have been designed for better efficiency, contact between rotor and stator is anticipated and accommodated by disposing a seal, such as a brush seal or an abradable seal, between these components. Abradable seals applied on the stationary parts of the gas or steam

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turbines have been used in order to allow the components from the rotating part (e.g. bucket tips, shaft teeth, etc.) to come into contact with the stator without suffering significant damage or wear. Contact between rotating elements and the abradable seal results in trenches worn into the abradable seal, creating a tight clearance between the two.

[0004] Effects such as thermal distortion of the casing and vibrations due to rotor dynamics often cause the path of relative rotor motion to become circumferentially non-uniform with respect to the stator. This non-uniformity of motion can lead to substantial contact in preferential, localized areas of the stator, resulting in undesirable amounts of component wear. A number of approaches have been tried to compensate for this non-uniform motion and resultant prevention of contact. Conventionally, machine parts have been machined circular and assembled with generous uniform clearances to prevent contact. The large clearances allow for more gas or steam to escape, however, which degrades system performance. In certain cases, parts are machined off-center to provide non-uniform clearances, but this complicates their fabrication and significantly boosts costs. In some steam turbines, seals are segmented into 4, 6, 8, or more segments, and the segments are each machined to a different diameter. This greatly complicates turbine assembly because individual parts must be tracked and assembled insitu in their specific circumferential locations. Therefore, what is needed is a cost-effective stator component that is capable of producing non-uniform rotor clearances. A further need is for efficient methods for making such components.

BRIEF SUMMARY OF THE INVENTION

[0005] Embodiments of the present invention meet these and other needs.

[0006] One embodiment of the invention is a stator component for a turbine assembly. The stator component comprises an annular base component having an inner surface that is substantially circular in axial cross-section and a coating disposed on the inner surface

of the base component. The coating has an interfacial surface in contact with the inner surface of the base component and an outer surface opposite the interfacial surface. The coating also has a thickness that varies as a function of circumferential position along the inner surface of the base component.

[0007] A second embodiment of the invention is a method for making a stator component for a turbine assembly. The method comprises providing an annular base component having an inner surface that is substantially circular in axial cross-section and disposing a coating on the inner surface of the base component. The coating has an interfacial surface in contact with the inner surface of the base component and an outer surface opposite the interfacial surface. The coating has a thickness that varies as a function of circumferential position along the inner surface of the base component.

[0008] These and other aspects, advantages, and salient features of the present invention will become apparent from the following detailed description, the accompanying drawings, and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] Referring now to the figures wherein like elements are numbered alike:

Figure 1 is a schematic view illustrating one embodiment of non-uniform spray coating disposed on stator base component;

Figure 2 is a schematic view illustrating another embodiment of non-uniform spray coating disposed on stator base component.

DETAILED DESCRIPTION OF THE INVENTION

[0010] In the following description, like reference characters designate like or corresponding parts throughout the several views shown in the figures. It is also understood that terms such as "top," "bottom," "outward," "inward," and the like are

words of convenience and are not to be construed as limiting terms. Moreover, it will be understood that the illustrations are for the purpose of describing a particular exemplary embodiment of the invention and are not intended to limit the invention thereto.

[0011] Referring generally to Figs. 1 and 2, embodiments of the invention address the needs described above by providing a stator component 20 for a turbine assembly 40. The stator component 20 comprises an annular base component 60 which, in certain embodiments, comprises at least one of a shroud, a turbine casing, and an annular assembly of turbine nozzles. The base component has an inner surface 80 that is substantially circular 90 in axial cross-section 100; and a coating 120 disposed on the inner surface 80 of base component 60. The coating 120 has an interfacial surface 140 in contact with the inner surface 80 of the base component 60 and an outer surface 160 opposite the interfacial surface 140. Coating 120 has a thickness 180 that varies as a function of circumferential position along the inner surface 80 of the base component 60, and as a result the shape of the outer surface 160 of coating 120 departs from the circular shape of the base component 60 to more closely conform to eccentricities in the motion of the rotor, thereby providing the tightest possible clearances during service. Embodiments of the invention allow parts to be machined round and on-center, and it is the coating 120 that provides the desired non-uniform rotor-stator clearance during assembly and operation.

[0012] Experience with certain types of turbomachinery has revealed that in many cases the rotor tends to follow an elliptical path of travel. Accordingly, to better conform clearances to this condition, in some embodiments of the present invention the outer surface 160 of the coating 120 is substantially an ellipse 220 in axial cross-section 100. The elliptical shape of the coating outer surface 160 is achieved by disposing a coating having a maximum thickness at the peripheral position where clearances are desired to be smallest (i.e., regions on opposite sides of the minor axis 260 of the ellipse) and a minimum thickness in areas needing the maximum clearance (i.e., regions on opposite sides of major axis 280). In certain embodiments, the base component 60 comprises a

top portion 300 and a bottom portion 320 that are joined together by a horizontal joint 260, and the ellipse formed by the outer surface 160 of the coating has a major axis 280 running between the top portion 300 and bottom portion 320. Although conventional approaches as described above often machine a circular stator to the desirable elliptical shape, or assemble a complex, multi-segmented stator to achieve an elliptical shape, the application of a coating as described herein offers significant advantages in cost and simplicity.

[0013] The thickness 180 of the coating 120 is up to about 3mm and in particular embodiments up to about 1.75mm. In one embodiment of the invention, coating 120 comprises an abradable material 130. Abradable coatings are widely known in the art and are used for their ability to provide seals between parts with relative motion. An abradable material is defined as one that selectively and sacrificially wears away under rotor-stator contact leaving behind a profile matching that of the eccentric motion of the rotor. Extremely tight seal clearances are obtained as a result. Exemplary abradable coatings are described in United States Patent 6,547,522. In one embodiment, the abradable material comprises a metal matrix phase and at least one secondary phase. In one embodiment, the metal matrix phase comprises at least one alloy selected from the group consisting of cobalt-nickel-chromium-aluminum (CoNiCrAlY), nickel-chromium-iron-aluminum (NiCrFeAl), and nickel-chromium-aluminum (NiCrAl). In one embodiment, the secondary phase comprises graphite. In other embodiments, the at least one secondary phase comprises at least one of a ceramic, a polymer, and a salt. In one embodiment, the ceramic comprises at least one of hexagonal BN, aluminosilicates, and calcined bentonite clay. In other embodiments, the polymer comprises at least one of polyester, polyimide, polymethyl methacrylate, silicone, siloxane, and rubber. In still further embodiments, the salt comprises at least one of aluminum phosphate and aluminum hydroxide.

[0014] In one embodiment of the invention, the coating 120 comprises a spray coating. Many different spray techniques suitable to produce coating 120 are known in the art. In

certain embodiments the spray coating comprises at least one of a plasma-sprayed coating, a flame-sprayed coating, a high velocity oxygen fuel (HVOF) -sprayed coating, a thermal-sprayed coating, and a wire-arc sprayed coating.

[0015] In order to take full advantage of the features described above, a further embodiment of the present invention is a stator component 20 for a turbine assembly 40. The stator component 20 comprises an annular base component 60 having an inner surface 80 that is substantially circular 90 in axial cross-section 100; and a coating 120 comprising an abradable material. Coating 120 is disposed on the inner surface 80 of the base component 60 and has an interfacial surface 140 in contact with the inner surface 80 of the base component 60 and an outer surface 160 opposite the interfacial surface 140. The outer surface 160 of the coating 120 is substantially an ellipse 220 in axial cross-section 100 having a major axis 280 running between top 300 and bottom 320 portions of the base component 60.

[0016] Other embodiments of the present invention include a method for making a stator component 20 for a turbine assembly 40. The method comprises providing an annular base component 60 having an inner surface 80 that is substantially circular 90 in axial cross-section 100, and disposing a coating 120 in the inner surface 80 of base component 60. The coating 120 has an interfacial surface 140 in contact with the inner surface 80 of base component 60 and an outer surface 160 opposite the interfacial surface 140. Coating 120 has a thickness 180 that varies as a function of circumferential position along the inner surface 80 of base component 60.

[0017] In one embodiment of the invention, coatings are deposited using a spray coating technique as described above. To achieve non-uniformity in thickness, the spray coating is, in some embodiments, applied using a robot that is programmed to vary the number of times the spray gun passes over specific arc lengths of the circumference. Each of these so-called "passes" typically deposits a coating layer ranging from about 20 μ m to about 80 μ m thick. For instance, the clearance is varied by roughly 200 μ m by

applying about 5 more coating layers over certain areas of the casing than over other areas. Also, the arc length of each coating layer is varied from layer to layer, to provide a relatively smooth transition between the areas of thick coating and the areas of thin coating

[0018] While typical embodiments have been set forth for the purpose of illustration, the foregoing description should not be deemed to be a limitation on the scope of the invention. Accordingly, various modifications, adaptations, and alternatives may occur to one skilled in the art without departing from the spirit and scope of the present invention.